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Report of the Workshop on Synthesis of Hydrographic, Phytoplankton, Microbial Plankton and Zooplankton Time Series in the North Atlantic and Adjacent Seas (WKSERIES)

15–18 October 2013

ICES Headquarters, Copenhagen, Denmark

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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Executive summary

The Workshop on Synthesis of hydrographic, phytoplankton, microbial plankton and zooplankton time-series in the North Atlantic and adjacent seas (WKSERIES), chaired by Alexandra Kraberg and Lidia Yebra, met at ICES Headquarters, Copenhagen, Denmark, on 15–18 October 2013. The principal aim of WKSERIES was to synthesize hydrographic, phytoplankton, microbial plankton and zooplankton time-series for the North Atlantic and adjacent areas. The concept for the workshop was conceived during the annual WGPME and WGZE working group meetings in Malaga, Spain 2012. Both groups met simultaneously and held several joint sessions.

The workshop analyses were based on the time-series data collected by the WGPME and WGZE expert groups. Several time-series have already been analysed using a range of statistical approaches while others have seen little 'interrogation'. As analyses from the different individual approaches are difficult to compare, a common time-series analysis approach was adopted for the WKSERIES workshop. The structure of the time-series used is very different (time-series length, gaps in coverage, different sampling frequencies and strategies) and exploratory analyses were therefore run before estimating the spectral properties of all datasets and fitting models to the data to estimate trends and climatology. All analyses were run in R (TSA and TTA interface). The suitability of the chosen statistical tool suite will be tested in follow-up analyses on a standard set of physico-chemical and biological data.

The preliminary workshop analyses were carried out for sites in the German Bight, English Channel, Skagerrak and offshore from the Eastern Scottish Coast which are all located in different Atlantic Inflow/impact regions. In addition, the zooplankton time-series in Málaga (W Mediterranean) was also analysed, as it is influenced by Atlantic waters entering the Gibraltar Strait. These analyses will be developed further using standardized results report sheets. Based on the results further sites/parameters will be added before summarizing the analyses for a peer reviewed publication.

There is consensus that hydrodynamic variation is a key element of the dynamics, including numerical model representation of the key abiotic time-series. Based on our discussions we recommend that there should be closer links between the relevant ICES working groups (hydrography, oceanography, zooplankton and phytoplankton) and we will propose a further workshop to explore the links between observed patterns in our time-series with hydrographic conditions.

1 Opening of the meeting

The ICES Workshop on Synthesis of hydrographic, phytoplankton, microbial plankton and zooplankton time-series in the North Atlantic and adjacent seas (WKSERIES) took place at ICES Headquarters, Copenhagen, Denmark, from 15 to 18 October 2013. The meeting was attended by 12 scientists representing 5 countries (for details see the List of Participants, Annex 1).

The meeting started on Tuesday at 9:00. The participants were welcomed by Jannica Haldin who summarized logistics of the meeting. Alexandra Kraberg (locally) and Lidia Yebra (via Webex), co-chairs, opened the meeting and welcomed the participants to Copenhagen.

2 Adoption of the agenda

The agenda for the WKSERIES meeting (see Annex 2) followed the Terms of Reference adopted as a resolution by the ICES SCICOM (2012/2/SSGEF11).

Following a round of introductions, the agenda was discussed briefly and adopted by the participants. The Terms of Reference for this workshop were to:

a) Review plankton and hydrographic time-series data in ICES and adjacent areas;

b) Identify relevant time-series analysis techniques;

c) Analyse variability and trends in plankton and hydrographic conditions;

d) Analyse variability and trends in distribution and phenology for the different taxa;

e) Review trophic interactions amongst taxonomic or functional groups within the time-series;

f) Discuss pan-regional trends in hydrography, phytoplankton, microbial plankton and zooplankton distribution and timing (seasonality);

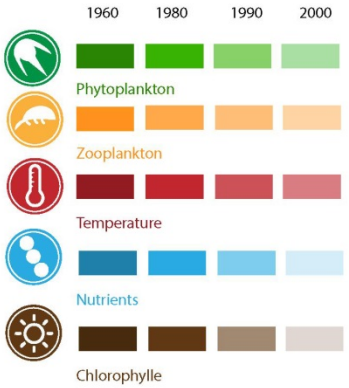
g) Prepare one or more synthesis papers that summarize the state of lower trophic levels and their relationship to hydrography and other environmental properties.

3 ToRs a) to g)

3.1 ToR a) Review plankton and hydrographic time-series data in ICES and adjacent areas

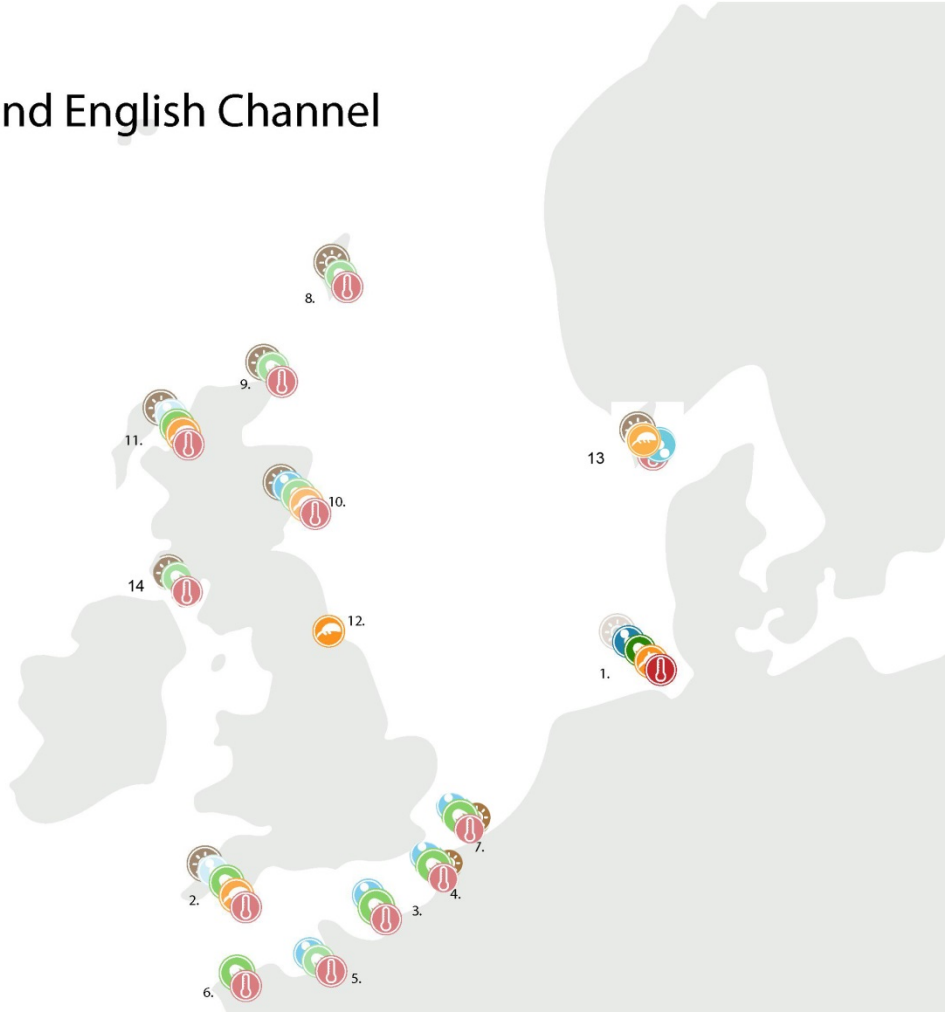
Rapporteur: Alexandra Kraberg

As the time-series in both groups were very heterogeneous and only had a partially overlapping distribution, a meta-analysis was carried out to visualize the data enabling the participants to devise feasible research questions. The data from all time-series were first summarized according to time-series location, separating graphs into greater biogeographic regions (North-West Atlantic, North Sea, Baltic.) For each greater region all data from the two working groups were summarized in terms of the measured parameters (coloured symbols) and length of the time-series (dark vs light shading).

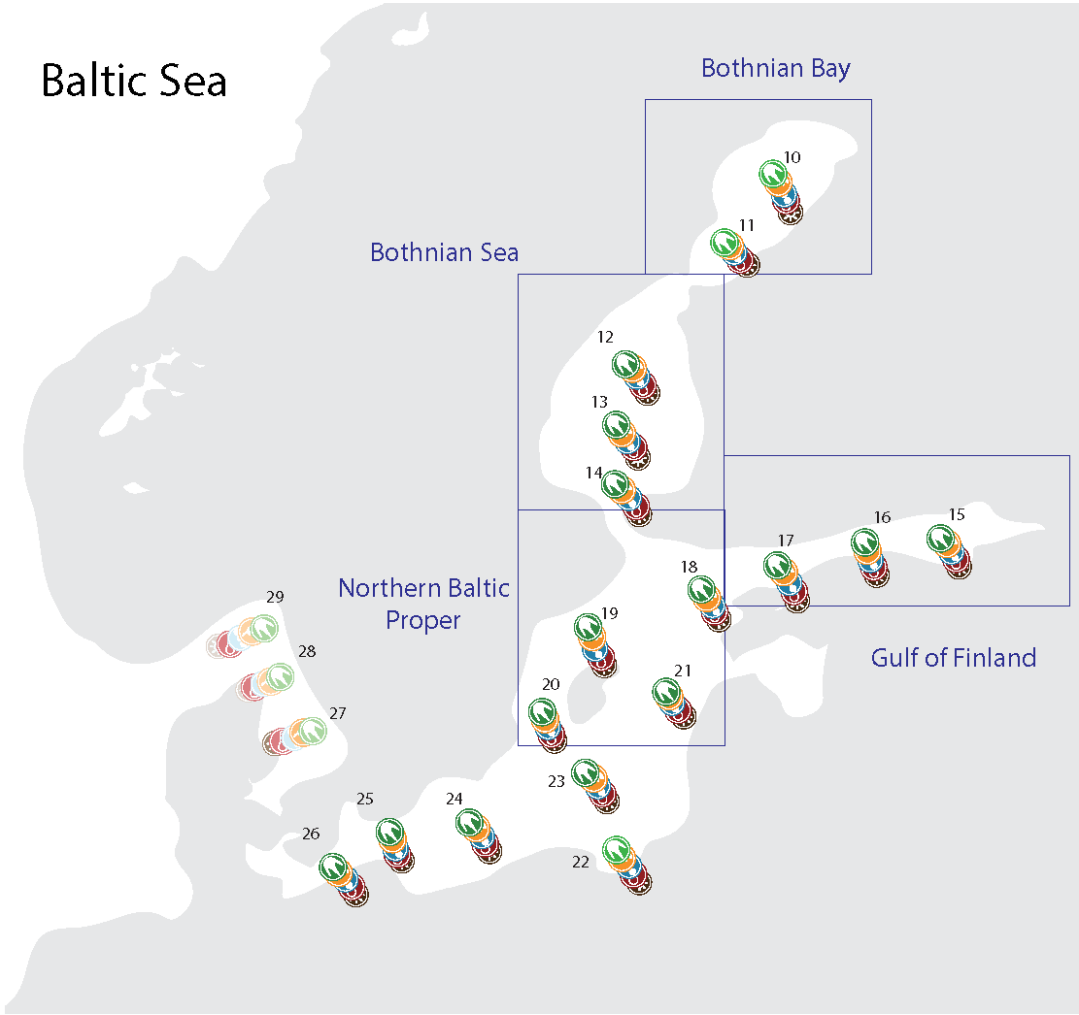


1	Helgoland Roads
2	Plymouth L4
3	REPHY Antifer Ponton Petrolier
4	REPHY At So
5	REPHY Donville
6	REPHY Pen al Lann
7	REPHY Point 1 SRN Boulogne
8	Scalloway - Shetland Isles
9	Scapa Bay - Orkney
10	Stonehaven
11	Loch Eve
12	Dove
13	Arendal Station
14	Millport

North Sea and English Channel



10-11	Bothnian Bay Region: F2+Bo3
12-14	Bothnian Sea Region: US5b+SR5+F64
15-17	Gulf of Finland Region: LL3A+LL7+LL12
18-21	Northern Baltic Proper Region: LL17+LL23+BY15+BY38
22	Gdansk Basin
23	Eastern Gotland Basin
24	Bornholm Basin
25	Arkona Basin
26	Mecklenburg Bight
27	SMHI Anholt East
28	SMHI Slaggo
29	SMHI A17



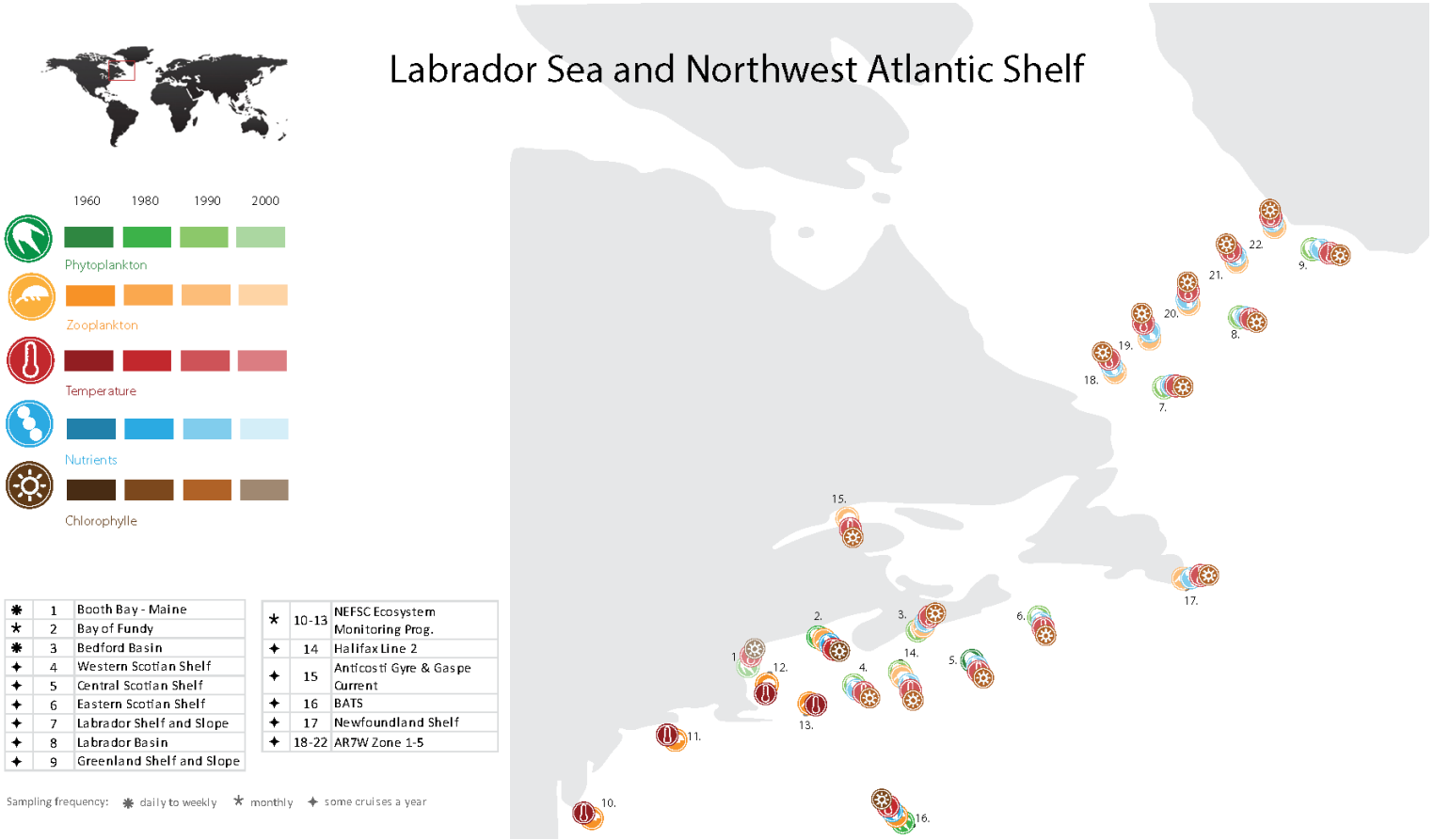


Figure 1. Summary plots of the time-series from WGPME and WGZE that are available to WKSERIES.

3.2 ToR b) Identify relevant time-series analysis techniques

Rapporteur: Alexandra Kraberg

During the workshop a set of standardized techniques had been explored to analyse the chosen time-series. One of the foci of the workshop was to explore links between biological patterns and potential underlying hydrographic drivers and the five stations in Figure 2 are ideally located to investigate this as they are influenced by different water masses characterising the current patterns inflow/outflow into/from the North Sea (Stonehaven in the NW North Sea, L4 and Gravelines in the English Channel, Helgoland Roads in the German Bight and Arendal Station in the Skagerrak).

To ensure the analyses a set of standardized techniques was applied:

1) Visual inspection/comparison of the time-series. This included a discussion of how to treat issues such as missing data (e.g. filling in with median of whole time-series, eigenvector filtering etc.). The use of remote sensing data to complement very 'gappy' time-series was also discussed but time did not permit to pursue this further.

2) Analysis of spectral properties of each time-series

3) Use Box-Jenkins transfer method to fit model/trend to underlying data

4) Derive Harmonic climatology

5) Also estimate non-symmetric properties where appropriate

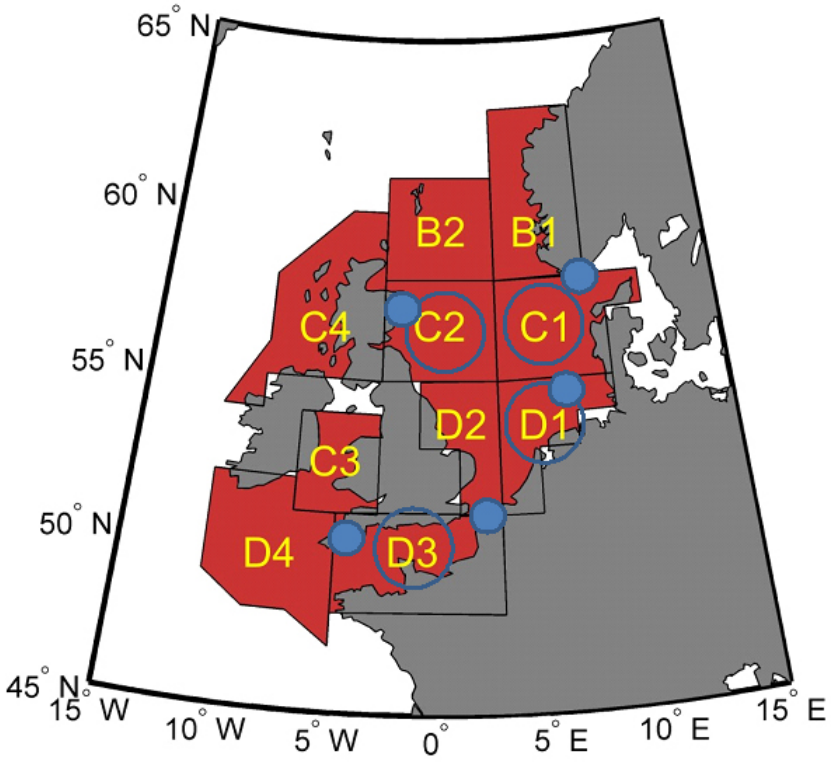


Figure 2. Map showing the locations of the time-series analysed during the WKSERIES workshop. The labelled boxes refer to the SAHFOS standard areas of which 4 (circled in blue) were included in the analyses. In addition, the shorter zooplankton time-series in Malaga (W Mediterranean) was included in the analyses (location not shown in Figure).

3.3 ToR c) Analyse variability and trends in plankton and hydrographic conditions

Rapporteur Kathryn Cook

Introduction:

Mirco Scharfe gave a presentation on long term simulations/spatiotemporal variations in hydrodynamic characteristics illustrated using the Coast Dat database for assessment of marine weather and hydrodynamics (www.coastdat.de www.hzg.de).

Global weather and radiation, regional atmospheric, wind speed and hydrodynamic models can be used to construct currents, tides, transport of water masses etc over decades, either to fill gaps in observations, or as an extension of time period. Results of a particle drift simulation model of the North Sea between 1962 to 2004 showed periods where the origin of water at Helgoland was very different, e.g from the north or from the Channel. EOF analysis of particle pathways can be used to identify spatial patterns of coherent time variability, patterns of transport of water masses, and the impact of different water masses.

There was a discussion about whether the model could be used to estimate the time taken for Atlantic water to circulate the North Sea, and whether the model could be extended to other areas. Mirco thought that the model could be extended but would need to look into it further, for example the precision of the model and whether validation measurements have been made in the Channel. He also commented that the model gives a good basis for forming hypotheses. Information about the model presented is available as several publications and reports and is currently being extended to include 1948 to 2012.

John Bruun led a session on an approach to analyse longer term time-series structure in ICES WKSERIES planktonic time-series applying harmonic time-series modelling and Box Jenkins transfer functions using the TSA package in R. The analysis will be applied to each data set, assessed to verify that the results make sense, and discussed with the group of experts present in order to establish a standard analysis that can be described in a recommendations paper. The group discussed the steps that would be followed during the rest of the workshop:

Alain Lefebvre noted that the TTA interface (R package) could also be used for steps A1-3 and at step 4 both methods could be used and compared. John felt that he needs to understand the TTA interface more before he could recommend/compare, because comparing the two methods is not comparing like for like. Also, it is important to be able to capture the seasonal pattern to identify years that have different peaks/season etc. otherwise inferences can only be made for the long-term trend. Alain and John agreed that the TTA interface and TSA methods have different objectives and that combining the two could provide a really useful toolkit. Alex Kraberg noted that we are not saying that one method is the right method but we are testing methods, as we all have knowledge of the biology in our areas, to produce recommendations. Pierre Helaouet recommended eigenvector filtering as a powerful method of filling in gaps. Based on this discussion the steps were modified and both TSA and TTA interface modules will be tested. The agreed procedure to be applied to/tested on the chosen datasets was as follows:

Steps A: baseline and trend characteristics

1) Exploratory analysis using TTA interface and TSA packages in R.

2) Agree how to fill in gaps, low frequency data might need filling in using TTA interface, TSA or eigenvector filtering in some cases.

3) Identify harmonic components with periodgrams using the TSA (R) toolbox (harmonise with TTA interface?)

4) Run the Box-Jenkins transfer function model using TSA and interpret results and/or seasonal Kendall test using TTA interface

5) Derive the harmonic climatology from the model.

6) Obtain the trend estimate.

(Steps 5 & 6 are using outputs from step 4)

7) Interpret the result so far using expert knowledge which is really important to progress discussions on what is happening in an area.

8) Repeat with NSAIM model where appropriate.

Steps B: Assess the anomaly (departure from a reference point)

1) Plot the residual structure of the time-series.

2) Are there similar patterns in our time-series from different locations?

3) Start to identify clusters of environmental characteristics, i.e. some structure we may be able to explain.

Data analyses:

As the preparation of the time-series data for this analysis required some time, only preliminary analyses were carried out to test the feasibility of the approach for the available data.

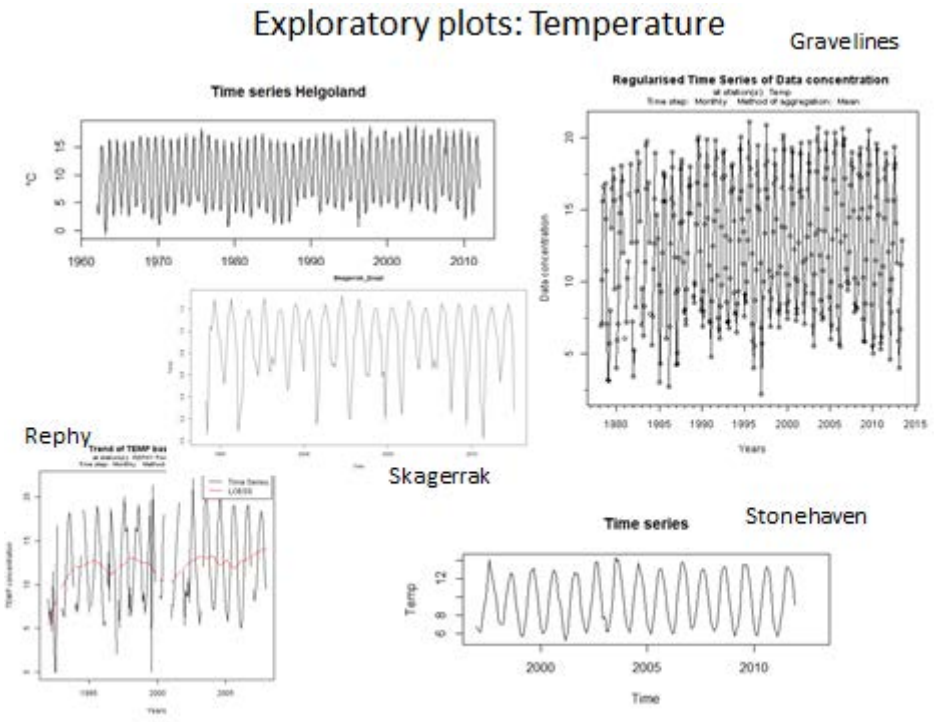


Figure 3. Summary exploratory analyses of time-series for 5 different stations.

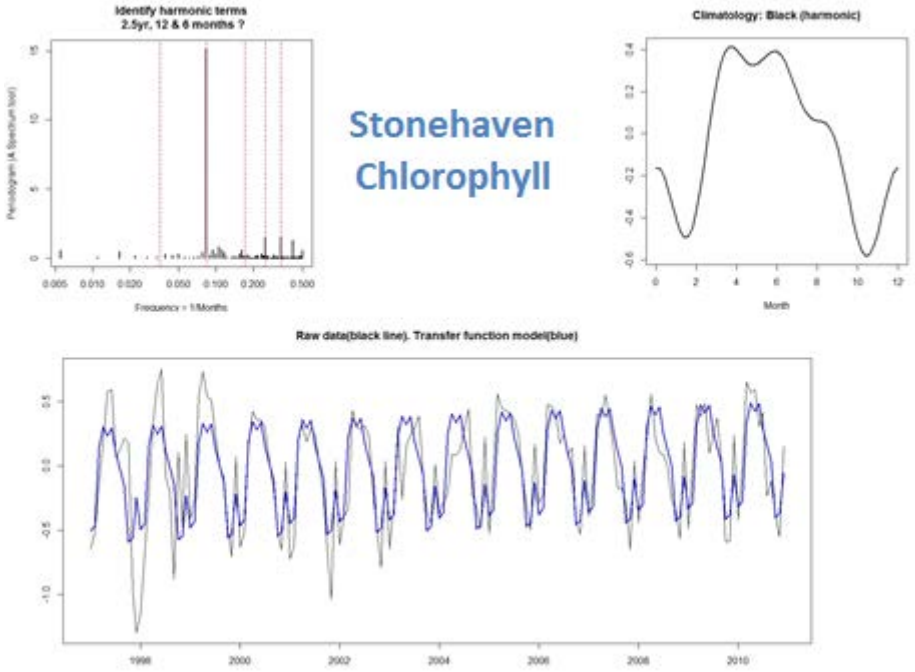


Figure 4. Example of a run of spectral analyses to identify significant cyclical behaviour and its frequencies in the time-series, as well as harmonic climatology and trend estimate.

3.4 ToR d) Analyse variability and trends in distribution and phenology for the different taxa; ToR e) Review trophic interactions amongst taxonomic or functional groups within the time-series; ToR f) Discuss pan-regional trends in hydrography, phytoplankton, microbial plankton and zooplankton distribution and timing (seasonality)

The accomplishment of these ToRs will be pursued by correspondence. Specific details are provided in section 4 (Next steps). The success of this ToR depends on the availability of phyto- and zooplankton data in comparable areas so that shifts in phenology, match-mismatch phenomena etc. can be analysed. We will address this issue based on the outcome of the analyses of the standard parameter list agreed below (Next steps).

3.5 ToR g) Prepare one or more synthesis papers that summarize the state of lower trophic levels and their relationship to hydrography and other environmental properties

It is planned to publish the results the activities described above. However, the concrete planning phase will begin after the analyses using the agreed standardized tools and parameters have been completed. It will then be discussed with modellers (already in the team as well as additional experts); (see Annex 3: Recommendations), which additional datasets might be integrated into the analyses. There are two papers envisaged, one with a specific analysis of conditions in the North Sea and one manuscript taking a broader approach.

4 Next steps

In order to meet the goals set in our ToRs, a series of steps have been agreed to be followed up (by correspondence) after the workshop:

1) A set of physico-chemical parameters as well as taxa (at different levels of taxonomic resolution), which will be analysed using the standard method by individual partners were agreed as follows:

a. total chlorophyll, temperature and salinity

b. abundance data for phytoplankton (log and untransformed time-series)

c. phytoplankton: total *Guinardia* and *Leptocylindrus* abundance, *Phaeocystis* spp., *Pseudo-nitzschia* spp., total *Protoperidinium* and total *Ceratium* as a proxy for the abundance of microzooplankton (total microzooplankton is not recorded very consistently between time-series, but the genera *Protoperidinium* and *Ceratium* usually are). In addition, the ciliate *Mesodinium rubrum* will be included, as again this can be identified reliably in most circumstances.

d. zooplankton: total abundance, total copepods, *Calanus finmarchicus* and *C. helgolandicus*, *Pseudocalanus*, *Oithona* spp., *Temora longicornis*, *Centropages hamatus*.

2) The results will be reported back using a standardized report sheet to ensure that all information will be comparable and complete. The reporting sheet will be distributed to all partners by the end of 2013. The following information will be included:

a. Standard time-series metadata

b. Exploratory graphs and statistics: box plots using medians (TTA interface)

c. Plots: trends, significant temporal signals,

3) The significance of the results will be explored further using hindcast models to link the detected patterns and trends to the underlying hydrography

3a. To do this further data sets from key areas will be sought. These include:

Fair Isle Inflow

Faroe Shetland Channel

Norwegian Trench Atlantic Inflow

Dover Strait

The planned follow-up work from this joint workshop will conceivably culminate in a recommendation for a more permanent multidisciplinary working group focussing specifically on the links between biological responses and physical drivers.

Annex 1: List of participants

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Annex 2: Agenda

Tuesday October 15, 2013

09:00 – 09:30 Meeting Open, Introductions, Logistics, Adopt Agenda

09:30 – 10:30 Short presentations from each participant/time-series (5-7 minutes)

1. Plankton monitoring in the western English Channel: Station L4

2. SAHFOS plankton recorder surveys

3. An analysis of drivers and shifts of phytoplankton community composition based on the Helgoland Roads Long Term Data

4. Marine Scotland Science Coastal Ecosystem Monitoring Programme: Observed variability in the phytoplankton community

5. Marine Scotland Science Coastal Ecosystem Monitoring Programme: Observed variability in the zooplankton community

6. Temporal variations in the zooplankton community at Arendal Station 2, northern Skagerrak

7. France Eastern Channel Zooplankton time-series

8. Discontinuous time-series in Málaga Bay (Alboran Sea, W Mediterranean Sea)

10:30 – 11:00 Coffee Break

11:00 – 12:00 Review plankton and hydrographic time-series data in ICES and adjacent areas (ToR a)

12:00 – 12:30 Discussion

12:30 – 14:00 Lunch

14:00 – 15:00 Statisticians talks

9. John Bruun

10. David Devreker

15:00 – 15:30 Identify relevant time-series analysis techniques (ToR b)

15:30 – 16:00 Coffee Break

16:00 – 17:30 Discussion, distribution of people and tasks in relation to analytical ToRs

Wednesday October 16, 2013

09:00 – 10:30 Analyse variability and trends in plankton and hydrographic conditions (ToR c)

11. Short introduction talk by Mirco Scharfe

10:30 – 11:00 Coffee Break

11:00 – 12:30 Continue to Analyse variability and trends in plankton and hydrographic conditions (ToR c)

12:30 – 14:00 Lunch

14:00 – 15:30 Analyse variability and trends in distribution and phenology for the different taxa (ToR d)

15:30 – 16:00 Coffee Break

16:00 – 17:00 Continue to Analyse variability and trends in distribution and phenology for the different taxa (ToR d)

17:00 – 17:30 Discussion

Thursday October 17, 2013

09:00 – 10:30 Presentation of results ToR c

10:30 – 11:00 Coffee Break

11:00 – 12:30 Presentation of results ToR d

12:30 – 14:00 Lunch

14:00 – 15:30 Review trophic interactions amongst taxonomic or functional groups within the time-series (ToR e)

15:30 – 16:00 Coffee Break

16:00 – 17:00 Continue to Review trophic interactions amongst taxonomic or functional groups within the time-series (ToR e)

17:00 – 17:30 Discussion

Friday October 18, 2013

09:00 – 10:30 Discuss pan-regional trends in hydrography, phytoplankton, microbial plankton and zooplankton distribution and timing (seasonality) (ToR f)

10:30 – 11:00 Coffee Break

11:00 – 12:30 Continue to discuss pan-regional trends in hydrography, phytoplankton, microbial plankton and zooplankton distribution and timing (seasonality) (ToR f)

12:30 – 14:00 Lunch

14:00 – 15:30 Prepare one or more synthesis papers that summarize the state of lower trophic levels and their relationship to hydrography and other environmental properties (ToR g)

15:30 – 16:00 Coffee Break

16:00 – 17:00 Prepare one or more synthesis papers that summarize the state of lower trophic levels and their relationship to hydrography and other environmental properties (ToR g)

17:00 – 17:30 Discussion and Closure

Annex 3: Recommendations

Recommendation	Adressed to
1. A joint workshop exploring the links between plankton long-term trends and hydrography. This workshop should not just focus on conceptual issues but be a practical workshop to explore these links statistically and through hindcasts e.g. using the Coastdat database and other tools. A joint biology-hydrography session should then also be considered for a future ASC meeting.	SCICOM, WGOH

Annex 4: Summary of visual inspection of time-series plots

WIKISERIES, Copenhagen October 15-18, 2013

Thursday October 17

Rapporteur: Tone Falkenhaug

The group spent the morning on identifying baseline and trend characteristics in the time-series, by applying identical analysis on all time-series (according to script passed around by John).

Results from this analysis were compared and discussed in plenum.

Stonehaven, phytoplankton:

- Chlorophyll: A regular seasonal pattern was found in Chlorophyll. Some anomalous years were identified with lower or higher abundances.
- Dinoflagellates : regular seasonal pattern. Some anomalous values. We need to consider how to deal with zero values in winter.
- Diatoms: A clear shift was identified in the seasonal pattern: -from a 2-peak (summer/autumn) to a 3-peak seasonal pattern (spring/summer/autumn)

Gravelines 1993-:

- Chlorophyll : No long term trend were found, two peaks per season (April, August)
- Diatoms: No long term trend was found, but a small 3 year-cycle was identified. The seasonal pattern did not show two peaks (as in Chlorophyll), but instead a prolonged period of high density from April to August.
- Centropages : An increasing trend was identified. The seasonal pattern showed a prolonged period of high density from April to July
- Euterpina: No long term trend observed. One seasonal peak in August-September.

Skagerrak, zooplankton (1994-):

- Total copepods: Seasonal pattern with two annual peaks. Long-term cycles of 18 and 9 years.

The harmonic climatology is out of phase 1994-2000, which indicates that a shift in the seasonal timing/pattern has occurred around year 2000.

Stonehaven: zooplankton

- Total copepods: A regular seasonal pattern. No long term trend
- Oithona: A regular seasonal pattern. An increasing trend was identified.

- Pseudocalanus: A 6-year cyclus was identified: quite noisy data.
- Calanus helgolandicus: No trend was observed. Subannual regularity: 1 year, 4 months, 6 months cycles.

L4: Zooplankton

- Calanus (C. helgolandicus): increasing trend

L4: Phytopankton

- Chlorophyll: Two peaks per year: spring/summer
- Diatoms: A decreasing trend in diatoms was identified, but only on untransformed data. The transformation of data needs to be evaluated. Different transformation produced slightly different results: A weaker transformation than Log10 may be preferred.
- Dinoflagellates: A strong annual freqquency. A weak 6-month cyclus were present. No trend was found.
- Ceratium and other various species: Variable, without any clear trend.
- No clear trend in salinity on this station

Malaga:

- Salinity: Subannual regularity

From the discussion:

Proposed hypotheses and research questions?

- The analysis could be used in order to test Atlantic vs coastal influence on the North Sea. This influence may vary geographically and through time. The influence (Atlantic vs coastal) is linked to climate variability.
- Are there consistencies between data-series (locations)? We expect local differences, but do they link up?
- Different localities have different climatological signals (linked to hydrography).
- Similar physical forcing will affect local populations differently.
- One output from this could be a recommendation for future studies: evidence for small scale geographical variations calls for studies on more fine scale structure?

Helgoland Roads (Thursday afternoon, notes A. Kraberg)

Total diatoms and dinoflagellates: increasing trends, with an apparent shift in 1998, which requires further investigation.

Temperature also shows an increasing trend since 1962.